Accommodations Toolkit

Manipulatives: Research

This fact sheet on **manipulatives** is part of the *Accommodations Toolkit* published by the National Center on Educational Outcomes (NCEO). It summarizes information and research findings on manipulatives as an accommodation. This toolkit also contains a summary of states' accessibility policies for manipulatives (/nceo/accommodations-toolkit/manipulatives-policies).

What are manipulatives? Manipulatives can be either physical or virtual and are typically used to help with mathematical calculations.

- "Physical manipulatives (PMs) are 3D physical (real world) objects that students can touch" with their hands (Ha & Fang, 2018). Often, they are some forms of blocks used for counting.
- "Virtual manipulatives (VMs) are 3D computer graphics (virtual world) that students can see and manipulate on a computer screen" (Ha & Fang, 2018).
- There are also interactive virtual and physical manipulatives (VPMs) that combine the two types of manipulatives in which students can observe virtual manipulative in real-time while they handle physical manipulatives.

What are the research findings on who should use this accommodation? Research showed that the students who benefited most from using manipulatives often were students with learning disabilities (LD), autism spectrum disorder (ASD), or mild intellectual disabilities (Bassette et al., 2019; Bouck et al., 2018, 2020).

What are the research findings on implementation of manipulatives? Seven studies were located that addressed the effects of manipulatives use on student mathematics assessment outcomes.

- Three studies compared virtual and physical manipulatives with mixed findings. Bassette et al. (2020) found that some students with ASD were more efficient with app-based (virtual) manipulatives while others were more efficient with concrete (physical) manipulatives. However, another study found no difference in performance between an app-based and a hand-held manipulative (Bouck et al., 2018). The third study found that virtual and physical manipulatives were helpful for students with intellectual and developmental disabilities and improved independence in two-step addition and subtraction problems. However, the students struggled to generalize strategies across problems without using manipulatives (Long, et al., 2020).
- Four studies explored the effectiveness of virtual manipulatives and found that they improved student performance or increased speed. One study found that students with ASD completed more steps independently per minute during subtraction problems with help from an app-based manipulative than without the use of a manipulative (Bassette et al., 2019). Another study found that virtual manipulatives helped improve accuracy on long division problems for middle school students with LD (Bouck et al., 2020), while still another study found that virtual manipulatives were beneficial for teaching higher-order mathematical concepts to secondary students with LD (Satsangi, Hammer, & Hogan, 2018). Lastly, Satsangi, Hammer, and Evmenova (2018) found higher performance for students with LD who were solving multistep linear equations using virtual manipulatives than without.

What perceptions do students and teachers have about manipulatives? Five studies touched on teacher or student perceptions regarding the use manipulatives when taking an assessment.

- Two studies examined teacher perceptions of manipulatives. The findings were mixed regarding whether the teachers believed manipulatives were useful during assessment. Tindal et al. (2008) found that teachers felt strongly that the use of manipulatives during testing was potentially beneficial. Another study found that almost all teachers believed that physical manipulatives helped students learn early numeracy concepts, but

nearly half of these teachers indicated that students had difficulty using them during testing unless they had previously been used during math instruction (Jimenez & Stanger, 2017).

- Two studies examined the perceptions of students with LD regarding the usefulness of manipulatives. Both studies found that students considered them helpful. Ha and Fang (2018) found that students thought both virtual manipulatives and physical manipulatives were helpful. However, they preferred to use both virtual and physical manipulatives together instead of just using one or the other. Another study on virtual manipulatives found that many students with LD found virtual manipulatives helpful when solving math problems (Satsangi, Hammer, & Hogan, 2018).
- One study examined whether students with ASD preferred virtual or physical manipulatives. This study found that all students preferred using app-based manipulatives over concrete physical manipulatives, even when they performed better with physical manipulatives (Bassette et al., 2019).

What have we learned overall? The research showed that the use of either physical or virtual manipulatives improved mathematics performance. This accommodation may be especially helpful for students with LD, ASD, and mild intellectual disabilities. Both teachers and students perceived manipulatives of all kinds (i.e., virtual manipulatives, physical manipulatives, combination of virtual and physical manipulatives) as helpful. Virtual manipulatives were preferred by students, though students may be more likely to get the correct answer when using physical manipulatives. There is limited research on the effectiveness of physical manipulations during testing though several recent studies examined virtual manipulatives. All studies examined the use of manipulatives during math assessments; no research was found that examined the effectiveness of manipulatives for other content assessments (e.g., science). There is also a need for research on the use of manipulatives during assessment by students who are blind or have low vision. Students who are blind or have low vision often use manipulatives, but no research was found on the potential usefulness of manipulatives for this group.

Footnotes

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Research on manipulatives summarized here is also available in NCEO's searchable *for Students with Disabilities Bibliography* (https (https://nceo.info/Resources/bibliographies)://nceo.info/Resources/bibliographies (https://nceo.info/Resources/bibliographies)) and in NCEO syntheses of research (see summaries for: 1999-2001 (https://nceo.umn.edu/docs/OnlinePubs/TechReport34.pdf), 2002-2004 (https://nceo.umn.edu/docs/OnlinePubs/Tech45/Technical45.pdf), 2005-2006 (https://nceo.umn.edu/docs/OnlinePubs/Tech47/TechReport47.pdf), 2007-2008 (https://nceo.umn.edu/docs/OnlinePubs/Tech56/TechnicalReport56.pdf), 2009-2010 (https://nceo.umn.edu/docs/OnlinePubs/Tech65/TechnicalReport65.pdf), 2011-2012 (https://nceo.umn.edu/docs/OnlinePubs/Synthesis94/Synthesis94.pdf), 2013-2014 (https://nceo.umn.edu/docs/OnlinePubs/Report402/NCEOReport402.pdf), 2015-2016 (https://nceo.umn.edu/docs/OnlinePubs/NCEOReport412.pdf), 2017 (https://nceo.umn.edu/docs/OnlinePubs/NCEOReport418.pdf), 2018 (https://nceo.umn.edu/docs/OnlinePubs/NCEOReport423.pdf), 2019 (https://nceo.umn.edu/docs/OnlinePubs/NCEOReport433.pdf). See the reports and online bibliography for additional information about the criteria used to identify studies included in this fact sheet.

References

Bassette, L., Bouck, E., Shurr, J., & Park, J. (2019). Comparison of concrete and app-based manipulatives to teach subtraction skills to elementary students with autism. *Education and Training in Autism and Developmental Disabilities*, *54*(4), 391–405. http://www.daddcec.com/etadd.html (http://www.daddcec.com/etadd.html)

Bassette, L., Bouck, E., Shurr, J., Park, J., Cremeans, M., Rork, E., Miller, K., & Geiser, S. (2020). A comparison of manipulative use on mathematics efficiency in elementary students with autism spectrum disorder. *Journal of Special Education Technology*, *35*(4), 179–190. https://journals.sagepub.com/home/jst (https://journals.sagepub.com/home/jst)

Bouck, E., Park, J., & Stenzel, K. (2020). Virtual manipulatives as assistive technology to support students with disabilities with mathematics. *Preventing School Failure: Alternative Education for Children and Youth*, *64*(4), 28–289. https://doi.org/https://doi.org/10.1080/1045988x.2020.17621157

Bouck, E., Shurr, J., Bassette, L., Park, J., & Whorley, A. (2018). Adding it up: Comparing concrete and app-based manipulatives to support students with disabilities with adding fractions. *Journal of Special Education Technology*, *33*(3), 194–206. https://doi.org/10.1177/0162643418759341 (https://doi.org/10.1177/0162643418759341)

Ha, O., & Fang, N. (2018). Interactive virtual and physical manipulatives for improving students' spatial skills. *Journal of Educational Computing Research*, *55*(8), 1088–1110. https://doi.org/10.1177/0735633117697730 (https://doi.org/10.1177/0735633117697730)

Jimenez, B. A., & Stanger, C. (2017). Math manipulatives for students with severe intellectual disability: A survey of special education teachers. *Physical Disabilities: Education and Related Services*, *36*(1), 1–12. https://doi.org/10.14434/pders.v36i1.22172 (https://doi.org/10.14434/pders.v36i1.22172)

Long, H., Bouck, E., & Domka, A. (2020). Manipulating algebra: Comparing concrete and virtual algebra tiles for students with intellectual and developmental disabilities. *Exceptionality*. https://doi.org/10.1080/09362835.2020.1850454 (https://doi.org/10.1080/09362835.2020.1850454)

Sastangi, R., Hammer, R., & Hogan, C. D. (2018). Studying virtual manipulatives paired with explicit instruction to teach algebraic equations to students with learning disabilities. *Learning Disabilities Quarterly*, *41*(4), 227–242. http://journals.sagepub.com/home/ldq (http://journals.sagepub.com/home/ldq)

Satsangi, R., Hammer, R., & Evmenova, A. S. (2018). Teaching multistep equations with virtual manipulatives to secondary students with learning disabilities. *Learning Disabilities Research & Practice*, *3*(2), 99–111. https://onlinelibrary.wiley.com/journal/15405826 (https://onlinelibrary.wiley.com/journal/15405826)

Tindal, G., Lee, D., & Ketterlin-Geller, L. (2008). *The reliability of teacher decision-making in recommending accommodations for large-scale tests* (Technical Report No. 08-01). Behavioral Research and Teaching, University of Oregon. http://www.brtprojects.org/publications/dl/61 (http://www.brtprojects.org/publications/dl/61)

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